STO-D FACT SHEET

SUBMITTAL DATE: 29 NOV 2017

STO TYPE: STO-D

STATUS: COMPLETING

STO NUMBER: D.GRD.2015.36

TITLE: Force Protection Basing

SUBMITTING ORGANIZATION: U.S. Army Engineer Research and Development Center

STO START YEAR/ END YEAR: FY15-17

1. NARRATIVE:

1A. Short Description from Narrative Chart

The purpose of this Science and Technology Objective- Demonstration (STO-D) is to reduce time and manpower requirements for protection of Soldiers and critical assets during early entry operations in austere environments. In future conflicts, power must be projected despite anti-access/area denial (A2/AD) challenges, to effectively deter potential adversaries and prevent them from achieving their objectives. This requires that small units have expedient protective structures and better planning capabilities as they maneuver from multiple locations and domains. All force protection technologies will have baseline capabilities assessed in early FY15; followed by integration experimentation and demonstrations during FY15. The FY16 demonstration assessed the capability to protect a contingency base within objective metrics for time and manpower. The effort in FY17 included Doctrine, Organization, Training, Materiel, Leadership, Personnel, and Facilities (DOTMLPF) integration and the finalization of concept of operations (CONOPs) and tactics, techniques and procedures (TTP) for basing protection. CONOPs/TTPs for the phases of base setup, operation and maintenance, and retrograde/material reuse was documented in handbooks and planning tools that emphasized the most effective troop-to-task ratios. By FY17, all technologies were at TRL 6. Transitions where appropriate will be through PdM Force Protection Systems and PdD Contingency Base Infrastructure as well as the Army Facilities Components System.

1B. Detailed Description

The objective of this STO-D is to provide standardized protective structures and barriers for critical asset protection during early-entry operations in environments characterized by complex and urban terrain with constantly fluctuating situations and ongoing Stability Operations. Each design was optimized to minimize manpower and time-to-construct using Maneuver or Maneuver Support Forces and will have clearly defined NATO levels of protection. Additionally, a suite of dynamic simulation models was developed to optimize systems and provide an understanding of the interactions and interrelationships of the component systems of the base camp (protection, power/energy, water, waste, etc.), and to begin to address base camps on a holistic systems basis. Force protection/vulnerability assessment and planning tools were provided to assess vulnerabilities associated with a planned or existing base design. All force protection technologies had baseline capabilities assessed in early FY15; followed by integration experimentation and demonstrations during FY15. The demonstration in FY16 demonstrated the capability to protect a contingency base within objective metrics for time and manpower. The effort in FY17 included DOTMLPF integration and the finalization of CONOPs and TTPs for basing protection using experimental data. CONOPs/TTPs for the phases of base setup, operation and maintenance, and retrograde/material reuse will be documented in handbooks and planning tools that emphasize the most effective troop-to-task ratios. By FY17, all technologies were at TRL 6. Technologies were transitioned to PdM Force Protection Systems and PdD Contingency Base Infrastructure as well as the Army Facilities Components System thereby enabling these capabilities to reach the warfighter. The warfighter payoff is reduced troop-to-task allocations by providing pre-engineered, rapidly emplaced protective structures to increase Soldier availability for other missions. This STO-D effort reduced risk to Soldiers and critical assets at earlier phases of operations, and reduces time to retrograde the base with modular reusable protection available for relocation. Technologies from this STO-D allowed improved planning, troop-to-task management, and scheduling of protection and other contingency basing tasks, thus making the force more effective when projecting combat power.

1C. Additional Detail
The Force Protection Basing program was developed to leverage the force protection technologies of the Joint Deployable Force Protection (JDFP) program. The JDFP Program developed expedient protection solutions for combat outposts and patrol bases to defeat the effects of rockets and mortars. The Force Protection Basing research program matured some JDFP technologies from a TRL 5 to a TRL 6 and developed expedient protection solutions to defeat the blast and ballistic effects of artillery. Force Protection Basing developed the planning tools and decision support tools that will give the Soldier the ability to plan the construction, operation, maintenance, and retrograde of a contingency base. These tools provide the ability to assess appropriate troop-to-task ratios and ensure that mission success, protection for the contingency base, and quality of life are all achievable in an operationally feasible timeframe.

1D. Why should Army leadership care about this:
During full spectrum operations, to negate a threat’s anti-access/area denial (A2/AD) capability, the Army requires secure tactical bases serving as the physical location in the area of operations for power projection. Despite advances in seabasing, minimizing logistical footprints, and the ability to conduct simultaneous, distributed operations, the Army will continue to require contingency bases to project power. The warfighter requires a sanctuary to organize for and recover from combat operations. Many of the products/results from this STO-D have immediate warfighter impact due to the alternate transition paths for protective construction techniques and structures. It is important that Army leadership harness the manpower savings resulting from this effort by rapidly implementing the solutions across the Force. This STO-D provides interoperability and standardization that identifies troop-to-task Warfighter efficiencies in protection missions.

2. WHAT IS THE PROBLEM?
Since 1991, the United States (U.S.) has engaged in numerous military operations in the Middle East, Central Asia, Africa, Europe, the Pacific Basin, and the Caribbean. In many instances, the need to conduct these extended operations over time has resulted in U.S. forces remaining in these areas far longer than initially anticipated. U.S. ground forces will remain capable of full-spectrum operations, with continued focus on capabilities to conduct effective and sustained counterinsurgency, stability, and counterterrorist operations alone and in concert with partners.

Commanders have been managing contingency bases without the proper tools and acquiring short-term solutions that are not integrated, which contribute to overall contingency base inefficiencies. This ad hoc approach and lack of consistent standards, training, and equipment diverts Soldiers from their primary mission, is heavily dependent on contractor support to operate or maintain, and is not sustainable by the Army logistics system. In many cases, Commanders rely on U.S. and local national contractors to fill basing capability gaps. These contractors will not support basing at the most forward, high-risk, tactical locations. Subsequently, our small basing nodes are left vulnerable during these early entry operations, because it takes too long and too much manpower to protect critical assets at these locations while also providing acceptable quality of life conditions. The future force lacks the ability to adequately plan, design, and construct Tactical Operations Centers (TOCs), food and fuel storage, protective structures and perimeters, and others to meet the need of the small basing nodes. Currently, soldiers are developing and field engineering ad-hoc designs that are not efficient and unnecessarily absorb valuable maneuver and maneuver support force manpower, are inefficient to construct, and do not provide adequate protection.

3. WHAT ARE THE BARRIERS TO SOLVING THIS PROBLEM?
With combat troops historically being between 25-39% of the deployed force, but being nearly 90% of the occupants of an extra small base camp, most forces occupying small bases have limited or no unit level organic capability to plan, design and construct protective structures and harden critical assets, yet base defense needs always vary by mission, enemy, troops, time, terrain, and civilian (METT-TC), i.e. no one-size / type fits all. Engineer units should be capable of customizing designs, but they have not been given the guidance needed to perform required functions in the modern cluttered and complicated battlefield. Engineer specific manuals and publications have been diluted by operational research and theater specific TTPs thus appealing to a much broader audience. Additionally, engineers are task saturated with other missions preventing them from focusing on survivability improvements.

4. HOW WILL YOU OVERCOME THOSE BARRIERS?
This STO-D has integrated lightweight, rapidly emplaced protective structures earlier into the base plan by making optimized standard designs available for master planners and deployed engineers. It has demonstrated pre-engineered, protective structures that minimized troop construction time and can be Military Occupational Specialty (MOS) generic. It has demonstrated scalable passive protection techniques for multiple phases of the base lifecycle.

5. WHAT IS THE CAPABILITY YOU ARE DEVELOPING AND WHERE IS IT DESCRIBED?
This capability is associated with gaps, which specify the limited capability to rapidly establish, expand and protect bases and forces see Capability Needs Assessment (CNA) gaps 461238, 20390, 461064, and 461438). Separate from these gaps this capability also compliments elements of the Army Operating Concept. The Joint Operational Access Concept, Required Capability JOA-020 speaks to the ability to protect and, if necessary, reconstitute bases and other infrastructure required to project military force. Individual technologies address the capability gaps identified in the Theater Infrastructure Repair and Restoration (TIRR) Initial Capability Document (ICD) Catalog of Approved Requirements Documents (CARDS) # 06053, approved 18 October 2007; Contingency Basing ICD CARDS # 16155, approved 03 April 2013; the Integrated Unit, Base, Installation Protection (IUBIP) Detect, Assess, Defend (DAD) ICD CARDS # 1052, approved 2 October 2009; the ENFIRE Capability Production Document (CPD) Increment 1 CARDS # 06072; and the Capability Development Document (CDD) for the Rapid Deployable

Protection System (RDPS), CARDS # 1999, approved 23 May 2017. Standard contingency designs for protective structures are required by AR 415-16 “Army Facilities Components System (AFCS)”.

6. IDENTIFY ALTERNATIVE APPROACHES/TECHNOLOGIES TO ACCOMPLISH/ENHANCE STO OBJECTIVE(S).

At this time, no alternative approaches/technologies to accomplish the STO-D objective are known. An Analysis of Alternatives (AoA) will be pursued as each technology matures.

7. WHAT IS/ARE THE PRODUCT(S)/RESULT(S) OF THIS STO?

The products of this STO-D are: demonstrated expedient protective structures and the modeling and simulation capability necessary to reduce manpower and time to protect small units and their critical assets at contingency bases, graphical teaching aides (GTAs) for passive force protection TTPs tailored for implementation, and planning and analytical software tools and algorithms to assess base protection in complex terrain. Additional products are listed below:

- **Designs for expedient protective structures**
- **Rapidly deployable, lightweight, scalable protection materials**
- **Algorithms and decision support tools for protection and operation of contingency bases**
- **TTPs and GTAs for passive force protection technologies tailored for small unit implementation**

8. QUANTITATIVE METRICS RELEVANT TO THE PRODUCT(S)/ RESULT(S):

This 6.2/6.3 S&T program developed/demonstrated technology solutions to inform a Materiel Solution Analysis and pre-Milestone A activities within TRADOC for development of Joint Capabilities Integration Development System (JCIDS) Requirements (where deemed appropriate) to mitigate the Capability Gaps listed under paragraph 5 herein. The following table summarizes Metrics for measures of success of this STO-D. Note that because detailed JCIDS CDD Key Performance Parameters (KPPs) are not yet defined and approved, subsequently Army Objectives are not defined, and are only able to list the Requirements document that this research will inform. The Program Objectives have been developed by the research team based upon a balance between the broad requirements listed within a relevant ICD and the team’s understanding of the realm of the possible within the time and funding constraints of this STO-D.

Measure	Current	Effort Objective	Army Objective	TRL or SRL
Engineer hours to establish guard tower	284 Engineer hours	7.5 Soldier hours 80 Soldier hours	12 hours 96 hours	Start: 4 End: 6 Start: 4 End: 6
NATO STANAG 2280 Level of Protection for overhead cover	Level C4 mortar	Level C5 artillery	C5	Start: 4 End: 6
Time to assess perimeter barrier vulnerability to VBIED	High Performance Computational Models (HPC)	< 30 minutes	< 30 minutes	Start: 3 End: 5
Time to assess troop-to-task requirements for up to three courses of action for the contingency base plan	Independent stand alone tools used to asses areas of contingency basing	< 1 day	Integrated models linked to multiple databases	Start: 3 End: 5

The Army currently lacks standardized guard tower designs. Antiquated, labor intensive timber designs once existed in field manuals, but no longer meet operational tempo. Although these timber designs allowed a deployed unit to customize the desired observation height, they required the tools and skills only present in a vertical engineer unit. Often, engineers are not available for this particular task, subsequently leaving the base vulnerable. The JDFP program investigated a logistically optimized, expeditionary Modular Protective System (MPS) Guard Tower meeting the Initial construction level, but this technology does not satisfy all guard tower requirements. The MPS Guard Tower's fixed 14-ft observation height limits its use with tall perimeter walls. The MPS Guard Tower will continue to be matured to inform the RDPS Key Performance Parameters, but alternative solutions are needed for changing METT-TC conditions. This STO-D leveraged the guard tower standardization efforts already completed by the United Kingdom Ministry of Defence. The guard tower design demonstrated a TRL 6 technology that can be transitioned through AFCS as an alternative to the legacy timber towers. The objective is to remove dependency on vertical engineers by developing pre-engineered kits that do not require special tools or skills.

Recent conflicts have primarily necessitated protective structures with STANAG 2280 C4 levels of protection. Future conflicts will likely require higher levels of protection. Although considerable research has been dedicated to the development of overhead cover protective structures, none have addressed Level C5 performance. This STO-D has demonstrated troop-to-task optimized TRL 6 methods for providing overhead cover against Level C5 threats.

The Army currently lacks the tools to assess the vulnerability of perimeter barriers to vehicle-borne improvised explosive device (VBIED) attack. Threat evolution has resulted in a need for decision support tools that enable base commanders to make informed decisions related to road closure, facility closure, or additional perimeter hardening. Currently, these decisions are being made without suitable engineering models that describe the expected breaching response. This STO-D resulted in identifying the engineering models and packaging them into a decision support tool so that deployed small unit commanders can make informed decisions without having to rely upon reach back. A TRL 5 demonstration of the decision tool was provided that allows the force protection officer the ability to assess the situation in less than 30 minutes.

The Army currently lacks tools to rapidly assess troop-to-task requirements for various courses of action for the contingency base plan. Base camp planners need the ability to understand the impact on troop and resource availability as various courses of action are investigated. This STO-D produced a TRL 5 planning tool that enables up to three courses of action to be assessed within 1-day. Troop and resource availability was highlighted as outputs from the assessment.

9. HOW WILL PROGRESS BE ASSESSED?

Informal TRL progression was assessed through Lab, Proponent, and Transition partner interaction at experiment/assessment/demonstration events and periodic Home-on-Home briefs. Formal progress was assessed quarterly by the USACE Commander and annually by ASA(ALT).

10. WHAT IS THE POTENTIAL/ WARFIGHTER PAYOFF?

Pre-engineered, rapidly emplaced protective structures increase Soldier availability for other missions. This STO-D provided reduced risk to Soldiers and critical assets at earlier phases of operations. The STO-D also reduced time to retrograde the base with modular reusable protection available for relocation and improved planning, troop-to-task management, and scheduling of protection and other contingency basing tasks.

11. TRANSITION CONCEPT/PLAN:

Standardized protective structure, revetment, and barrier designs will transition to the AFCS Program Office for vetting by Joint services, approval by the Joint Operations Engineer Board (JOEB) and incorporation into the Joint Construction Management System (JCMS). AFCS and STO-D researchers will work with the AFCS provisioning leads to pursue item introduction National Stock Numbers (NSNs). Newly established NSNs will be incorporated into relevant GTAs for passive force protection TTPs and transitioned to the TRADOC Capability Manager – Maneuver Support (TCM-MS) for DOTMLPF integration through Centers of Excellence (CoEs) and the TRADOC schools.

With approval of the RDPS CDD on 23 May 2017 (CARDS # 1999), the Modular Protective System fulfills Key Performance Parameters (KPPs), Key System Attributes (KSA's) and subsequent Additional Performance Attributes (APAs) approved by the AROC. Researchers will now work with Product Manager, Force Protection Systems (PdM FPS) under guidance within the CDD's Program Summary (paragraph 4), to mature the RDPS acquisition program. Additional S&T improvements can be used to inform the TCM-MS and Maneuver Support Center of Excellence (MSCoE) RDD Protection Branch for RDPS Increment 2 and progress towards its objective KPPs.

Newly developed survivability planning and assessment software tools will be used to inform MSCoE on possible capability improvements for the ENFIRE Program of Record Increment 2 Requirement Document. These new software tools will provide an improvement to the Design Shelters and Bunkers Required System Function.

Standalone master planning and analysis capabilities developed as part of the Virtual Forward Operating Base (VFOB) software will be used for training in the U.S. Army Engineer School (USAES) Captain's Career Course, Reserve Officer Training Corps (ROTC) training, as well as

United States Military Academy curriculum. STO-D researchers delivered an integrated prototype Master Planning software capability for AFCS JCMS toolset under the soon to be signed VFOB Software TTA with AFCS.
Product Director Contingency Base Infrastructure (PdD CBI) recently held an Integrated Systems Requirements Review (I-SRR) to identify Critical Parameters needed in an integrated base camp planning tool notionally called CBIWar. Prototype protection software tools being developed within this proposed STO-D were demonstrated at the I-SRR demo in early FY15. Integration exercises were planned throughout FY17.

12. TESTING:
Live experimentation and assessments occurred periodically throughout the STO-D to inform capability and material developers, and to validate analytical models. Most of these activities occurred at the Maneuver Support Center of Excellence. Limited developmental testing of mature technologies were pursued through ATEC as required by the TRADOC proponent and transition partner. When possible, R&D experiments utilized threat munitions for weapons effects experiments to minimize costs during the scheduled testing phases.

The master planning, design and analysis toolset of this STO-D was utilized and tested by the 542nd Engineer Detachment – Forward Engineer Support Team – Advanced (FEST-A) during both home station training exercises as well as forward deployed missions. In addition, the toolset was tested during a 10-day support mission to the Task Force Essayons in Nov 2017.

13. MODELING AND SIMULATION:
It is currently planned that the Maneuver Support Battle Lab will use their Virtual Simulation Capability to understand the operational implications of the Force Protection Basing technologies. These types of simulations will highlight the operational impact of each technology's capability and feed Analyses of Alternatives (AoAs) and Cost Benefit Analyses (C-BA) as the acquisition programs progress. Further, the United States Military Academy at West Point has allocated an analyst from the Operations Research Center of Excellence (ORCEN) to complement the Maneuver Support Battle Lab (MSBL) simulations. The ORCEN will develop the work load model to quantify troop-to-task savings as new technologies are developed. With further coordination, it is possible that the Force Protection Basing problem space may be addressed by the Engineered Resilient Systems Community of Interest. This proposed STO-D is currently providing input to TRADOC Analysis Center at Fort Leavenworth (TRAC FLVN). TRAC FLVN is attempting to model threats, risks, and losses to infrastructure as they simulate Phase IV steady state operations. Finally, researchers within this STO-D use the DoD High Performance Computing Center on a daily basis to evaluate structural response to dynamic weapons effects. These high-fidelity models are often simplified to reduced-order models and response surfaces for implementation in fast-running decision support tools.

Master planning, design, and analysis capabilities that have been developed as part of this STO-D were utilized to support various DoD contingency basing research efforts. The VFOB Detailed Component Analysis Model (DCAM) is the primary simulation and analysis capability supporting Sustainability Logistics Basing – Science and Technology Objective – Demonstration (SLB-STO-D) effort co-led by the U.S. Army Natick Soldier Research, Development and Engineering Center (NSRDEC) and U.S. Army Engineer Research and Development Center (ERDC). VFOB-DCAM was also used to support the Energy Efficient Outpost Modeling Consortium (EEOMC), which is an Office of Naval Research (ONR) led consortium consisting of DoD, DoE, and academic and industry partners. Further, base camp resource requirements simulations performed by STO-D researchers were utilized to inform the Naval Surface Warfare Center (NSWC) Carderock-led Behavioral Energy Operations Demonstration (BEyOnD).

14. LEVERAGING OTHER PROGRAMS:

Several beneficial relationships grew from the Force Protection Basing Technology-enabled Capability Demonstration 1a Program. We recommend these R&D partnerships should continue as they will result in an integrated solution to Force Protection Basing. Some of the Communications-Electronics Research, Development and Engineering Center (CERDEC) and U.S. Army Armament Research, Development and Engineering Center (ARDEC) research programs have become key partners of the Integrated Base Defense and Contingency Basing Infrastructure integration efforts. The Army will benefit from keeping these programs closely aligned in the new STO-D environment. Additionally, this Force Protection Basing STO-D has provided starter funds to numerous industry partners through the Rapid Innovation Fund contracts. It is possible that some of these industry partners will continue with internal R&D funds. Some of the technologies developed by the Deployable Force Protection (DFP) program prematurely ended before they reached their full potential. Further maturation and technical data package transition is needed to make them enduring Army solutions. The primary focus of DFP was reduced logistics. Troop-to-task ratios for each technology were not completely assessed, so manpower implications of these technologies are not fully quantified. On an international front, the United Kingdom’s Defence Science and Technology Laboratory is currently collaborating with our researchers on vulnerability algorithm research related to base camp perimeters. Joint Improvised Explosive Device Defeat Organization (JIEDDO) and other US Government Agencies are actively monitoring ERDC’s research and may contribute funding to explore areas beyond our current funding capabilities. Additionally, ERDC researchers have access to and can leverage the Department of State’s R&D program, some of which is related to force protection on deployed base camps.

15. LOGISTICS IMPLICATIONS:

This STO-D had large implications on reducing logistics and logistics lead times due to the improved planning and systems approach to protection and base operations. Standardized designs, packaged in preconfigured kits were more easily addressed by the PdD CBI’s systems engineering team. In close coordination with the Total Army Analysis quantities, a meaningful quantity of Army pre-positioned stocks were provided to the appropriate managing PM’s, the Defense Logistics Agency, Class IV item managers. Pre-planned, pre-positioned stocks greatly reduced logistics delivery delays and optimized kitting reduced logistics. The model tool set developed allowed contingency base planners and designers to improve resource requirements through the life cycle of the operations based on location, duration, size, and mission-related needs. Additionally, the toolset allowed contingency base operators to forecast their mission needs based on changes to current operational tempo, population changes, and/or disruptions in resupply schedules and efforts. This allowed them to rapidly generate multiple courses of actions to achieve the most efficient base camp plan within the current mission environment

16. JOINT APPLICABILITY:

Yes. The Navy, Air Force, and Marines have exhibited interest in the standardization of protective structure facility and sustainment designs that will be transitioned through the AFCS JCMS. The AFCS Program Office has a process for bringing in new designs, requiring them to be vetted by sister services and approved the JOEB. Further, both Contingency Basing and Survivability Doctrine manuals have dual proponency through the Marine and Army Engineer Schools.

17. ENDORSEMENTS: (NAME, OFFICE, DATE)

- TRADOC – MSCoE – TCM Maneuver Support, COL Fischer
- TRADOC – MSCoE – CDID, COL Thompson
- Program Manager Army Facility Component Systems, Garth Anderson, Deputy
- PEO CS&CSS - Product Director Contingency Basing Infrastructure , Kathy Lytle, Director
- PdD CTIS, Bob Knowles, PdD
- PEO CS&CSS – Product Manager Force Sustainment Systems, LTC Poppenberger, PM
- PdM FPS, Mr. Rob Bednarczyk, Deputy PdM, 10 June 2016
- MG G. Martin, MSCoE, Commander
- MG J. Dorko, USACE DCG, Military and International Operations
- MG K. Cox, USACE DCG, Military and International Operations
- BG A. Funkhouser, USAES, Commandant
- Mr. S. Davis, PEO CS&CSS
- Mr. C. Rettie, NSRDEC Expeditionary Basing and Collective Protection Directorate, Director

18. POCS (STO MANAGER, TSO, PM, AND TRADOC SPONSOR):

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19. PERFORMERS/ CONTRACTORS: ERDC

- Watkins Technical Services
- Edwards Design and Fabrication
- Air Force Research Laboratory (AFRL)
- Dugway Proving Ground
- SOL Engineering Services, LLC
- Summerwind Consultants
- University of Sheffield
- Dr. Jim Davidson, Auburn University
- SIAC
- Dr. Steven Corns, Missouri University of Science and Technology
- The PERTAN Group, Champaign IL

20. FUNDING ($K):

Organization	PE/Project/Task	FY15 ($K)	FY16 ($K)	FY17 ($K)	Total ($K)
ERDC/GSL	62784/AT40/22TV	6,113	6,204	0	12,317
ERDC/GSL	63734/DT08/01TV	2,604	3,200	3,215	9,019
ERDC/CERL	63728/002/01TV	1,352	1,385	1,351	4,088
PM AFCS		1,800	250	250	2,300
	Total	11,869	11,039	4,816	27,724

21. WHAT ARE THE SUPPORTABILITY/RELIABILITY ISSUES OF THIS TECHNOLOGY?
No unique supportability/reliability issues are expected with this technology. Many of the technologies were transitioned through the AFCS Program Office and have obtained Class IV construction material NSNs. The AFCS Program Office will oversee item provisioning and lifecycle maintenance to prevent NSN obsolescence. Some early entry base protection technologies will be planned to be managed by Acquisition PM's, but selective items will be stored in pre-positioned stocks. These technologies do not have supportability issues.

22. ANNUAL PROGRESS REPORT:
This STO-D was executed as planned. The FY17 fund obligation goals have been met as of end of October 2017. No major changes have occurred within FY17 and actual accomplishments tracked with the planned accomplishments and ultimately led to meeting exit criteria for the STO-D. Major tasks of planned vs. actual accomplishments are listed below in the following table.

FY17 Planned Accomplishments	FY17 Actual Accomplishments
Integration of protection modules into VFOB	Integration of protection modules into VFOB
PPVT Wizard	PPVT Wizard
MPS Guard Tower Assessment	MPS Guard Tower Assessment
Integration of contingency base technologies into dense urban research programs	Integration of contingency base technologies into dense urban research programs
MPS-OHC and EET Construction Assessment	MPS-OHC Fielded
Validation of full span MPS-OHC to Level C5 artillery	EET Construction Assessment
Pre-detonation blast reduction experiments	UFC 1-201-01 rewrite (on-going)
Simplified Survivability Assessment – Overheard Cover App including pre-detonation	TMPAST II blast, fragmentation, and sensor placement modules (on-going)
	Validation of full span MPS-OHC to Level C5 artillery
	Pre-detonation blast reduction experiments
	Simplified Survivability Assessment – Overheard Cover App including pre-detonation

23. END OF PROGRAM REPORT:
The total cost for the STO-D was $27.8 million with the funding provided as noted in section 20. The STO-D produced:

- Two kitted guard tower solutions that can be constructed in under 80 man hours with no special equipment:
    - The Modular Protective System (MPS) Guard Tower which is a military occupational specialty (MOS) unspecific, pre-engineered kitted tower with a 7 ft deck height constructible in 7.5 Soldier-hours.
    - The Elevated Expeditionary Tower (EET) which is a MOS unspecific, pre-engineered kitted tower with a 14 ft deck height constructible in 80 Soldier-hours.
- A kitted overhead cover system, Modular Protective System Overhead Cover (MPS-OHC), which provides protection up to STANAG 2280, level C5 artillery and is compatible with the Modular Protective System wall kits, concrete Alaska barriers, or soil-filled barriers for spans of up to 52.5 ft.
- The Barrier Damage Assessment Module which is a fast-running (less than a minute) decision support tool for predicting the breach width in perimeters made of soil-filled barriers or concrete barriers due to VBIED.
- High-fidelity computational models to predict perimeter barrier vulnerabilities to VBIEDs within 24 hours for complex barrier constructions.
- Software tools for basecamp planning and protection:
    - Virtual Forward Operative Base (VFOB): a planning, layout, and analysis tool for contingency basing master planning including aspects of all of the tools below
    - Detailed Component Analysis Model (DCAM): a tool for resource requirements simulation and analysis
    - Protection Planning, Visualization, and Assessment Tool (PPVAT, “pivot”): a tool for deployed forces integrating a protection planning process with visualization and various assessment apps including aspects from all of the tools below
    - Threat Mapped Protection Assessment and Simulation Tool II (TMPAST II): a tool to perform rapid analysis of threat from asymmetric weapons and determine the optimal placement of assets, defensive fortifications, and sensor systems relative to threat for holistic protection
    - Combat Outpost/Patrol Base (COP/PB) Planner: a tool to perform threat analysis based on terrain and select protection countermeasures based on JCMS facilities
    - Deployed Forces – Risk Management Tool (DF-RMT): a tool for implementing Army Risk Management process for base camps
    - Base Assessment, Design, Analysis, and Planning Tool (BaseADAPT): a tool for protection visualization and scheduling
    - Simplified Survivability Assessment Overhead Cover App: Application for the design of overhead cover for foxholes which includes new methods reducing the amount of sandbags needed
    - Serpentine Barrier Separation App: Application to determine the separation distance needed between barriers in order to achieve a desired vehicle speed
    - Vehicle Barrier Selection App: Application to aid in the selection of vehicle barriers for the protection of a base camp
    - Standoff Assessment App: Application that provides a fast, initial estimate of the minimum standoff (or separation) distance required between a user-defined blast source and typical base camp assets to achieve a desired protection level
- A vehicle barrier solution, Field-Expedient Non-Lethal Vehicle Arresting Barrie (FENVAB), that can be constructed in theater using Class IV materials rated to ASTM F2656-07 M30

- A prototype kitted vehicle barrier solution, Aggressor Vehicle Entry Readiness Technology (AVERT) Barrier System, that has been validated at the component level
- An extra-small base camp protection technology demonstration site at TA-190, Fort Leonard Wood, Missouri, Base Defense Assessment Site (BDAS), for proponent assessments; concept of operations and tactics, techniques, and procedures development; and troop training exercises
- Field Expedient Overhead Cover Solutions for specific operational situations using Class IV materials and/or shipping containers to provide protection from indirect fire
- Blast response curves for ISO Container Shelters and SEA Huts/B Huts on extra-small and small basecamps

Additionally, research from this STO-D is informing the UFC 1-201-01 rewrite

The products above have been transitioned as follows:

- The guard tower and overhead cover system solutions heavily informed the Rapidly Deployable Protection System (RDPS) Capability Development Document (CDD). A technology transition agreement was signed with Product Manager Force Protection Systems (PdM FPS) in April 2016. The RDPS CDD was approved 23 May 2017, and the systems will transitioned to PdM FPS. In addition, the systems will be transitioned to Army Facilities Components System (AFCS).
- MPS- Overhead Cover (OHC), MPS Guard Tower, and MPS wall kits have been transitioned to the Warfighter through the Defense Logistics Agency and the Rapid Equipping Force. MPS is additionally of interest to the Warstopper Program.
- The Barrier Damage Assessment Module was released on the U.S. Army Corps of Engineers Reachback Operations Center (UROC) Reachback Engineer Data Integration (REDi) Force Protection Portal in September 2015 and has been transitioned to the National Ground Intelligence Center (NGIC), Department of State (DoS), Joint Improvised-Threat Defeat Agency (JIDA), U.S. Army Training and Doctrine Command (TRADOC) Capability Manager-Maneuver Support (TCM-MS), U.S. Army Network Enterprise Technology Command (NETCOM) Protection Cell, 158th Security Forces Squadron, 406th Army Field Support Brigade, 934th Security Forces Squadron, 429th Expeditionary Operations Squadron, U.S. Army Europe (USAREUR) G-3, Letterkenny Army Depot, Combined Joint Task Force-Operation Inherent Resolve (CJTF-OIR), 46th Engineer Battalion, U.S. Central Command (CENTCOM) J-3, 10th Mountain Division, and U.S. Army Engineer School. The Barrier Damage Assessment Module is also integrated within the planning tools developed in this STO-D.
- High-fidelity computational models to predict perimeter barrier vulnerabilities to VBIEDs have been used on multiple to answer requests for information from theater to either aid in protection planning or aid in post-event forensic analysis.
- The protection planning tools meet needs within the Integrated Ground Security, Surveillance, and Response Capability (IGSSR-C). It is likely that the tools will transition to Product Manager Electro Optic Infrared Payloads for IGSSR-C. In addition, the simplified tool will be transitioned to the Warfighter directly through the UROC REDi Force Protection Portal and the advanced user tool will be used to answer requests for information from theater.
- Applications have been transitioned to ENFIRE and the Warfighter through the UROC REDi Force Protection Portal.
- Drawings of the vehicle barrier solution made Class IV materials will be transitioned to AFCS.

- The kitted vehicle barrier solution will be transitioned to a future research program for further development and to complete system level validation.
- The contingency basing master planning tool has been transitioned to AFCS.
- A standalone version of the Defense Medical Logistics Standard Support) Customer Assistance Module (DCAM) has been transitioned to Sustainability Logistics Basing (SLB)-STO-D.

APPENDIX A

Modular Protective System (MPS)
Technology Transition Agreement (TTA)

Between

Product Manager Force Protection Systems (PdM FPS)
5900 Putnam Road, Bldg. 365
Fort Belvoir, VA 22060

And

US Army Corps of Engineers

Engineer Research and Development Center
Geotechnical and Structures Laboratory
3909 Halls Ferry Road, Bldg. 3396
Vicksburg, Mississippi 39180

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1. Executive Summary:

The Modular Protective System (MPS), developed by a team from the Army Engineer Research and Development Center (ERDC), is the precursor to the Rapid Deployable Protection System (RDPS) Program of Record (POR). It is a reusable, scalable protective barrier capable of rapid emplacement. This Technology Transition Agreement (TTA) highlights the MPS Technology deliverables of key interest to Product Manager Force Protection Systems (PdM FPS) and the Integrated Base Defense (IBD) mission. A TTA is normally completed at the beginning of the development of a technical product, however, the MPS was initially fielded by the Rapid Equipping Force (REF), without an enduring requirements document. In an attempt to include the product into the long term Army protection efforts, this TTA is being completed late in the process. A Capability Development Document (CDD) for the RDPS is being written and the MPS has been shown to be the initial solution for that product. The key deliverables from the MPS effort are Wall Kits and Overhead Cover kits currently in use at the Soldier Protection Lab, U.S. Army Aviation and Missile Research, Development and Engineering Center (AMRDEC) located at Redstone Arsenal, AL. PDM FPS will work closely with ERDC, the Maneuver Support Center of Excellence (MSCoE), and appropriate Project/Product Managers for the synchronization of materiel solutions and their implications to Doctrine, Organization, Training, Materiel, Leadership and Education, Personnel, and Facilities (DOTMLPF).

2. Operational Need:

Soldiers are exposed to enemy direct and indirect fire weapon systems while on small bases. While earth-filled or concrete barriers provide force protection on large Forward Operating Bases (FOBs) where heavy engineer equipment support is available, no materiel solution exists for providing sidewall and overhead protection in remote locations where front end loaders, fill materials and cranes are unavailable. Near-miss and direct hits on unprotected areas have caused casualties and damage to equipment. Soldiers need a lightweight protective barrier that can be quickly assembled without any equipment. Filling soil-based systems by hand is unrealistic and prolongs the vulnerability of our troops. As a result, MPS was developed to fulfill a requirement by the REF.

3. Proposed Technical Solution:

The protective system will be configurable for protection of a wide variety of base assets and scalable for varied protection levels as demanded on small bases and in early entry operations in austere environments. It should include a scalable wall system that provides full protection from small arms and blast/fragmentation protection from near-miss mortars and rockets, Personnel Borne Improvised Explosive Devices (PBIED), Vehicle Borne Improvised Explosive Devices (VBIED), and vehicular impacts. The scalable wall system and the overhead cover protection for direct hits does not exist on small bases. The MPS is currently assessed at a Technical Readiness Level (TRL) 6, has received Budget Activity 3 (BA3) Advanced Technology Development funds and has been fielded through various rapid acquisition efforts. TRL 6 is defined as the demonstration of the system/subsystem model or prototype in a relevant environment. MPS has been engaged in Force Basing Architecture as a part of the Contingency Base Infrastructure (CBI) and Integrated Base Defense (IBD) portfolios. To facilitate availability during the transition

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period, the ERDC is working closely with the Defense Logistics Agency (DLA) to obtain Class IV National Stock Number (NSN) designations for all of the Asset-Specific MPS Kits described below. Currently, NSNs exist for the Wall Kit and Mortar Pit.

A. Wall Kit: A 45-ft long x 8-ft high wall kit, packaged within a Tricon, multiples of which can be used for perimeter protection or configured as desired for sidewall protection of any asset.

B. Sidewall and Overhead Cover (OHC) Configuration: This kit, referred to as MPS-OHC, will completely protect a 20-ft by 20-ft area, packaged within standard 20-ft ISO containers or Tricons. It can also be scaled to protect wider and longer assets.

C. Personnel Inspection Station: For Entry Control Points (ECPs), utilizing three of the standard wall kits (Tricon contained) described above.

D. Expedient Mortar Pit: Packaged within a Tricon.

E. Elevated Guard Tower or Ground-Level Fighting Position: Packaged within a Quadcon that also provides the elevated support for the tower.

4. Transition Target Information:

MPS will provide capabilities to support the following acquisition programs:

A. Rapid Deployable Protective System (RDPS): The MPS is proposed as the Government-owned solution for RDPS, whose CDD is currently under development at MSCoE. The PdM FPS is expected to be the program manager. The RDPS will provide capability to multiple PORs that require expedient, recoverable, non-earth-filled protection for critical assets. One such effort is the Base Camp Entry Control (BCEC). Still in the requirements development stage, the BCEC Capability Production Document (CPD) is being developed by MSCoE to address key base camp security and defense capabilities outlined in Initial Capabilities Documents (ICD), such as the Joint Contingency Basing ICD. It is anticipated that the RDPS will serve as one of several materiel solutions to meet BCEC requirements.

B. Integrated Base Defense (IBD): The IBD Trail Boss mission has been assigned to Program Executive Office Intelligence, Electronic Warfare and Sensors (PEO IEW&S) with Project Manager Terrestrial Sensors (PM TS) as the Trail Boss. PM TS has assigned PdM FPS to execute IBD kitting requirements, Operational Needs Statements (ONS) and associated REF 10 Liners. The IBD mission is based on Central Command's (CENTCOM) need for an integrated approach to Base Defense. PM TS is in close contact with all Program Executive Offices (PEOs) providing materiel solutions to Base Defense. The PM TS is synchronizing efforts for near term solutions, working with the other two IBD Trail Bosses and is leveraging the past efforts of the Systems of Systems Integrated Product Team (IPT) at the Assistant Secretary of the Army for Acquisition, Logistics and Technology (ASA (ALT)) level for the long term IBD mission.

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5. Transition Requirements:

One set of the existing MPS has been placed at the Soldier Protection Lab for demonstration and development purposes and to inform the RDPS CDD. Subject to BA4 funding availability, the ERDC will support PM TS and PdM FPS prior to and throughout the RDPS POR transition by:

A. Assessing the MPS capabilities against the Key Performance Parameters (KPPs) defined within the RDPS CDD

B. Coordinating Research and Development (R&D) activities to advance MPS capabilities toward those defined within the RDPS CDD

C. Assessing of industry-offered solutions to the RDPS Requirement

D. Developing of the CDD Refinements for the RDPS

E. Sharing Existing Test Reports/Study Data/Analysis Reports on the MPS and RDPS

6. Integration Strategy:

The MPS is entering the Acquisition Cycle within RDPS at Milestone B. The Program Element numbers and funding have yet to be defined. The MPS was originally developed by the ERDC through a 3-year 6.2/6.3 Army Technology Objective research program to provide the warfighter with a technology-based solution for rapidly deployable and recoverable passive protection in response to Theater-generated ONS and multiple warfighter interactions. This capability has been enhanced and demonstrated at the prototype level through the FY11-FY14 Deployable Force Protection (DFP) Program. The demonstrated MPS capabilities strongly informed the requirements described within the RDPS. PM TS is embracing the evolving RDPS Capability as a solution to passive protection requirements within the IBD construct and the evolving BCEC POR. No further 6.2/6.3-funded Science and Technology (S&T) development is planned for the MPS and the MPS technology will be transitioned to the PDM FPS as the Government Off-the-Shelf (GOTS) solution to the RDPS Requirement. The components of the MPS to be transitioned to PDM FPS are listed in paragraph 3 above. The RDPS CDD is still evolving, but it is clear that some of its Requirements (both Threshold and Objective) will not be met by the current version of MPS. Some of the anticipated required technology advancements are:

A. Weight Reduction for Standard Wall Kit: This kit currently weighs approximately 14,000-lbs (including Tricon). Objective total weight is less than 10,000-lbs in order to accommodate movement by the 10K forklift available on most bases.

B. Elevated Guard Tower or ground-level Fighting Position Protection Improvements: The RDPS lists requirements for additional levels of protection beyond the current capability to include rapidly-installed ballistic windows and full Rocket Propelled Grenade (RPG) protection.

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C. Long-span capability for the OHC: Currently, the modular OHC framework can cover clear spans of 12.5-feet, 20-feet and 27-feet. The RDPS CDD requires a clear span of 50-feet, with no special material handling equipment or special tools.

D. Armor and pre-detonation layer solutions: The armor and pre-detonation layer for the current version of MPS performs reliably against the specified threats but is not optimal in terms of shipping weight and volume. Depending upon RDPS Requirements, other armors and pre-detonation layers may be more desirable for the final system if cost becomes a lesser driver than shipping weight or volume.

7. <u>Benefits of the Modular Protective System (MPS):</u>

The MPS provides the warfighter with a government owned, modular solution for rapidly deployable and reusable physical protection that does not require heavy equipment for assembly. The MPS is a lightweight space frame augmented with composite armor panels to form protective barriers (walls) around critical base assets. The MPS has been validated for protection against most direct-fire small arms, indirect-fire mortars, small rockets, blast loadings from IEDs, and vehicular impact loadings. And, when augmented with a screening system, the standard MPS package has been validated to provide protection from specific shoulder-fired rocket threats. Protection is provided by a multi-layered armor panel system that allows protection levels to be tailored based on the threat level. All components in the system are one- or two-man portable and no material handling equipment or special tools are needed for system assembly/disassembly. A rapidly-erected OHC capability also exists to provide protection from direct hit heavy mortars and small rockets. Because of its modularity, the MPS provides a new protection "building block" that is adaptable to numerous base assets.

8. <u>Risks:</u>

A. Safety: In support of rapid acquisition and demonstration efforts, Army Test and Evaluation Command (ATEC) Safety Releases have been obtained for the MPS Wall, OHC, Mortar Pit, and Guard Tower. Potential safety issues identified by ATEC were: Adequate lifting strength is required to lift and handle certain MPS components; Some personnel may be limited in the material they can lift due to the weight of the space frames (70-lbs), the E-glass panels (108 or 105-lbs), and the assembled truss beams (210 or 268-lbs); Side and overhead panels slide within the rail frames and can pose a pinching or crushing hazard.

B. Survivability: Through numerous ERDC experiments, MPS armor configurations have been validated to fully defeat the effects of direct fire threats up to .50 caliber and the blast and fragmentation effects of 82mm, 120mm, 107mm, and 122mm mortars and rockets. When augmented with a screening system, the MPS has been validated to provide penetration and shrapnel protection from shoulder-fired rocket threats. The MPS has also been successful in defeating the blast and shrapnel effects of the international Usher standard for PBIEDs, blast effects from nearby VBIEDs, and vehicular ramming. Much of this has been confirmed with ATEC reports.

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9. Current Status of Technology/Product

Approximately $2.5M of MPS residual material is currently installed at Redstone TA6 for permanent use by PdM FPS. Another $1.6M of MPS material is located at MSCoE to support their experimental sites (TA 190 and CBITEC). The RDPS CDD is currently 90% complete. Once the total number of kits by type is confirmed, MSCoE will adjust the amounts/types and request a Life Cycle Cost Estimate (LCCE). The MSCoE is finalizing the 3 courses of action for the Cost Benefit Analysis (CBA) which will be used for LCCE development. After the LCCE and CBA are complete, MSCoE will conduct a murder board and finalize the CDD to send to worldwide staffing. The CDD is currently in 1 Star Staffing at MSCoE and will reach final approval in March 2017. This would allow for funding in the 19-23 POM.

10. Points of Contact:

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Pamela Kinnebrew Date
Lead Technical Director, Military Engineering
US Army Engineer Research and
Development Center (ERDC)

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APPENDIX B

DESCRIPTIONS OF DEMONSTRATIONS

1. Under TECD

a) BaseADAPT Demonstration (December 2012, Vicksburg, MS): BaseADAPT was demonstrated to 412th Base Camp Planners and other personnel for feedback

b) BaseADAPT Demonstration (September 2013, Fort Leonard Wood, MO): BaseADAPT was demonstrated to Engineer School/Officer's Course Staff

c) BaseADAPT Demonstration (September 2013, Champaign, IL): BaseADAPT was demonstrated to LTC Martin Jung, AFCS Design Integrator

d) FS-RMT Demonstration (March 2014, Fort Bragg, NC): FS-RMT was demonstrated and trained to US Army Special Operations Command antiterrorism officers

e) TSOA Shot Detection Event (July 2014, Fort Harrison, MT): Multiple Force Protection Basing technologies participated as fixed facility protection measures. The event objective was to collect acoustic, radar, optical and infrared data on each shot in an effort to develop new and enhance existing sensor systems intended to identify hostile fire on fixed facilities and locate point of origin for counter-fire.

2. Under STO-D

a) PdD CBI War Demonstration I (October 2014, Rock Island, IL): Software tools including: DF-RMT, BaseADAPT, TMPAST, COP/PB Planner, and VFOB were demonstrated

b) TA-190 Force Protection Demonstration (April 2015, Fort Leonard Wood, MO): STO-D technologies were demonstrated including: Line of sight denial screening, software tools, manpower model, EES, and MPS Guard Tower to visitors such as:

- MG Duane Gamble, Dep G4
- Dr. Rebecca Johnson, MSCoE DtCG
- COL Sydney Smith
- LTC Steve Kolouch
- LTC Jennifer Mitchell
- Mr. Nate Cornell
- COL Tommy Thompson, MSCoE CDID
- COL Tim Fischer, TCM-MS

c) DoD Lab Day (May 2015, Washington, DC): MPS was demonstrated as a part of DoD Lab Day at the Pentagon

d) Iron Warrior (FY15, Dugway, UT): The effects of VBIEDs on perimeter barriers, modular re-locatable buildings, and troop-constructed shelters were investigated and demonstrated in the IRON WARRIOR test series which was a multiagency collaboration led by the National Ground Intelligence Agency

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e) Vehicle Barrier Demonstration (November 2015, Fort Leonard Wood, MO): Two versions of the FENVAB were demonstrated to the TCM-MS

f) ART/TSOA 15.4 (September 2015, Fort AP Hill, VA): EET was demonstrated in ART/TSOA event

g) NIE/AWA 16.1 (September 2015, Fort Bliss, TX): The MPS Guard Tower, MPS Mortar Pit, and the EET were demonstrated in a tactical environment during a battalion-sized event. There were 114 distinguished visitors at the event (most notable: Honorable Katherine Hammack, Assistant Secretary of the Army (Installations, Energy, and Environment); GEN Dennis Via, Commander Army Material Command; GEN David Perkins, Commander TRADOC; LTG Herbert McMaster, Director Army Capabilities Integration Center; and multiple congressional representatives).

h) BDAS Demonstration (February 2016, Fort Leonard Wood, MO): Force Protection Basing Technologies were demonstrated at the Base Defense Assessment Site (TA 190) to visitors including MG Kent Savre

i) ART/TSOA 16-3 (May 2016, Muscatatuck, IN): The AVERT Barrier System was demonstrated in a live crash event

j) CBI War Integrated Demonstration (June 2016, Warren, MI): VFOB with integrated versions of BDAM and the DF-RMT were demonstrated

k) MPS Guard Tower Demonstration (November 2016, Fort Leonard Wood, MO): The slingload capability of the MPS Guard Tower was demonstrated as well as constructability and integration with other Army technologies

l) EET Assessment (March 2017, Fort Leonard Wood, MO): The constructability of the EET was demonstrated

m) Army Engineer Regiment Week (April 2017, Fort Leonard Wood, MO): MPS Guard Tower was demonstrated to Army Engineers

n) Marine Engineer & EOD Summit (May 2017, Quantico, VA): Protection software tools and capabilities were demonstrated to Marine Engineer and EOD officers

o) Overhead Cover Application Demonstration (June 2017, Fort Polk, LA): Live-fire testing on various overhead cover materials were completed to validate and demonstrate the capability of the Overhead Cover Application

p) Joint Integration Program Non-Lethal Protection Demonstration (September 2017, Fort Leonard Wood, MO): The AVERT Barrier System was demonstrated in a static event

APPENDIX C

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